Ecologically Coupled Vector Borne Disease Detection Using NASA Earth Science Enterprise Satellite Data

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Using near-real-time climate data and satellite imagery, NASA scientists are developing the ability to map and monitor eco-climatic patterns associated with various disease outbreaks and provide advance warning of outbreaks vitally important to human health and economics. For example, researchers at GSFC, in partnership with scientists at the Department of Defense have discovered that the combination of both warmer-than-normal Pacific Ocean temperatures associated with El Niño and the western equatorial Indian Ocean can trigger outbreaks of Rift Valley Fever (RVF) in Eastern Africa. Analysis of both ecological data using NOAA-AVHRR NDVI data and SST data indicates that large-scale outbreaks of RVF can be predicted up to five months in advance in Eastern Africa. In addition, they are finding strong evidence that transmission of mosquito-borne encephalitis viruses may be triggered by several specific events (such as surface temperature, precipitation, snow melt, and standing water), and are applying NASA's assets to study similar relationships between these parameters and other diseases such as Hanta virus and West Nile virus.

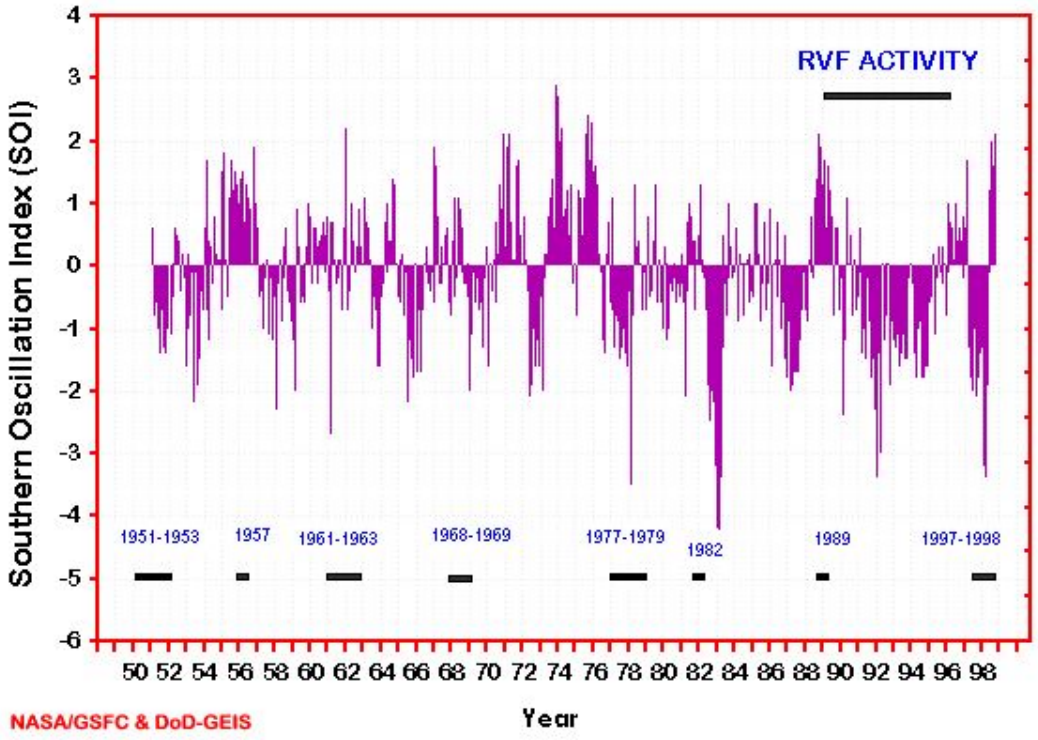
Anticipated Benefits:
The ability to identify maps and monitor eco-climatic patterns associated with disease outbreaks from satellite platforms will provide advance warning of outbreaks and would enable preventive measures (e.g. vaccination, vector control) to be undertaken. NASA satellite capabilities could save lives and identify emerging health threats and provide disease surveillance tools to public health authorities.

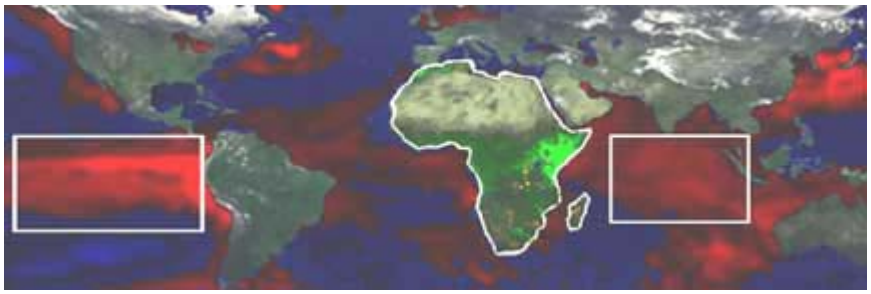
Current Projects:
1. Mapping Potential Rift Valley Fever (RVF) Outbreaks Using AVHRR-NDVI Data
2. Mapping Ecological Patterns Associated With St. Louis Encephalitis (SLE) Outbreaks In USA
3. Hanta Virus In The U.S. Southwest: Ecological Dynamics And Interannual Climate Variability

1. Mapping Potential Rift Valley Fever (RVF) Outbreaks using AVHRR-NDVI Data

Collaborators:
Kenneth J. Linthicum (Department of Defense)
Global Emerging Infections Systems (GEIS)
Walter Reed Army Institute for Research
Compton J. Tucker (NASA/GSFC)

Rift Valley Fever (RVF) is a viral disease that primarily affects domestic animals (cattle, sheep and goats) but occasionally causes disease in human beings in Africa. Outbreaks are devastating to the agricultural economies of rural East Africa and can cause significant human morbidity and mortality as was observed during the 1997/98 period. Outbreaks of RVF from 1950 (below) are known to follow periods of above normal rainfall associated with El Niño/Southern Oscillation (ENSO).





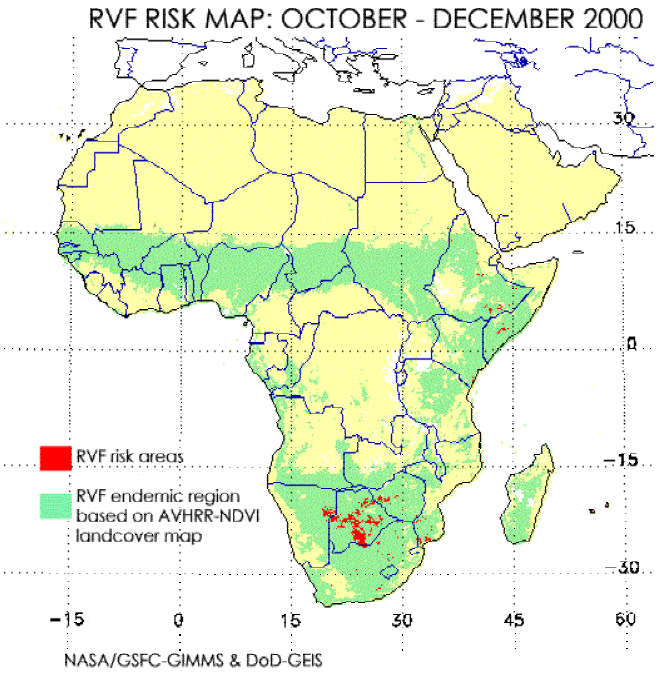
Data Source: NOAA/AVHRR Credit: NASA

Scientists have discovered that the combination of the warmer than normal water temperatures associated with El Nino and above normal sea surface temperatures in the western equatorial Indian Ocean can trigger outbreaks of Rift Valley Fever in East Africa. The two warm pools of water (highlighted in boxes above) increase rainfall in wide areas of eastern Africa, which can lead to large-scale outbreaks of the mosquito-borne disease.

Satellites provide synchronous measurements of ocean temperature and vegetation conditions. These images illustrate the close relationship between ocean temperature (warmer than normal ocean colors are shown in red, cooler than normal temps in blue), rainfall, and their impacts on land vegetation (greener than normal vegetation shown in green).

Using near-real-time climate data and satellite imagery showing changes in vegetation patterns and sea surface temperatures, predictions about emerging Rift Valley Fever epidemics in East Africa can be made several months before an outbreak occurs. The ability to forecast RVF virus activity 2 to 5 months before outbreaks occur could permit vaccination of domestic animals and implementation of appropriate mosquito control programs.

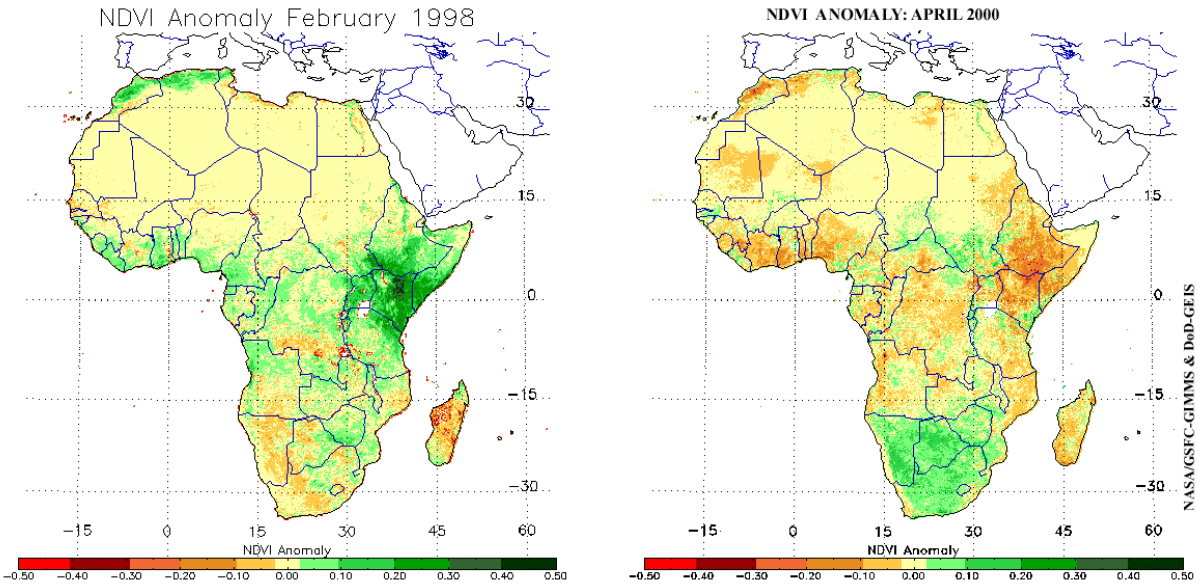
Maps of monthly NDVI anomalies, monthly climate indices (NINO3.4, Indian Ocean SSTs, SOI) Global OLR and SST anomaly maps are produces every month and posted to our web site: http://www.geis.ha.osd.mil. Public health official can utilize this information to target areas for field sampling of RVF viral activities thus cut down on the cost of surveillance.



This RVF risk map was derived from thresholding NDVI anomaly data. As previously shown by research periods of widespread and prolonged heavy rainfall precede RVF outbreaks (Linthicum, 1983). Since vegetation as shown by NDVI time series positively responds to such rainfall events (Justice et al, 1986) especially in semi-arid areas, we can use NDVI data as a measure of the magnitude and persistence of the anomalies associated with anomalous widespread and prolonged rainfall events.

The Vegetation Factor

By closely monitoring the vegetation in the region affected by the increased rainfall, scientists can identify the actual areas affected. Scientists use satellite images to show regions of Africa that are greener (and wetter) than normal or more brown (and drier) than normal.



Data Source: NOAA AVHRR / Normalized Difference Vegetative Index. Credit: NASA

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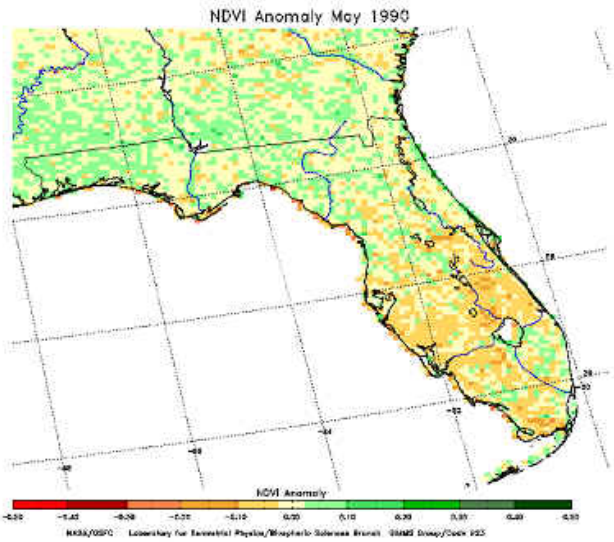
2. Mapping ecological patterns associated with St. Louis Encephalitis (SLE) Outbreaks in USA

Partners:
Compton J. Tucker (NASA/GSFC)
Jonathan F. Day, University of Florida, Medical Entomology Laboratory
Institute of Food and Agricultural Services

Mosquito-borne encephalitis viruses are responsible for numerous cases of human illness in North America and globally. There is strong evidence that transmission is triggered by specific meteorological events (surface temperature, precipitation, snow melt and standing water). The climatic parameters can be monitored and applied to prediction models to help forecast the risk of encephalitis epidemics in specific areas.



Scientists will be using AVHRR NDVI time series data to characterize the ecological and climatic conditions during outbreaks of SLE for the period 1981 - 1999 in Florida and intend to identify whether there are ecologically coupled (climate and vegetation) conditions that trigger SLE outbreaks.

The group of researchers is looking at extending this research to cover other regions of the US with known outbreaks and examining other diseases including Hanta virus and West Nile Fever and determine whether research results have any early warning potential for public health applications.

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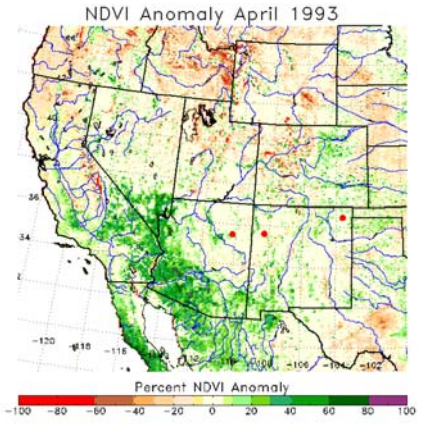
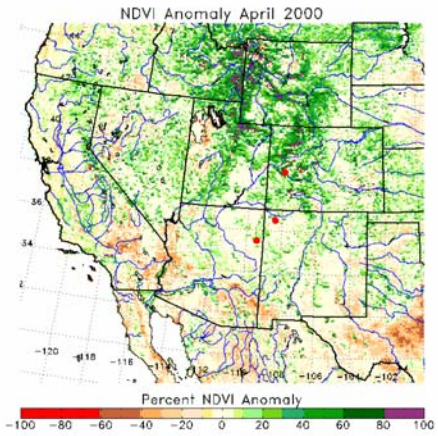
3. Hanta Virus in the U.S. Southwest: Ecological Dynamics and Interannual Climate Variability

Collaborators:
Compton J. Tucker (NASA/GSFC)
Kenneth J. Linthicum (Department of Defense)
Global Emerging Infections Systems (GEIS)
Walter Reed Army Institute for Research

Hantavirus Pulmonary Syndrome (HPS) has been recognized as a disease only recently (1993) in North America. Outbreaks have occurred in the U.S. Southwest Four Corners region. Rodents, especially the deer mouse, carry Hantaviruses that causes HPS. Infections typically occur via exposure to dear mice droppings. Emergence of large numbers of these rodents is associated with above normal precipitation in this region. Above normal rainfall in the U.S. Southwest is associated with El Niño/Southern Oscillation (ENSO). In this study, the variability in land surface ecology (inferred from NDVI) and its relation to ENSO (using SST data) and variability in precipitation over this region are being investigated to identify whether HPS outbreaks have occurred during periods of above normal NDVI/rainfall.





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